Science and Operational Applications Research (SOAR) Project
RADARSAT-2 DATA USE AND BENEFITS REPORTS
Canadian Space Agency

Project information and data

Date: July 22, 2013
Project Title: Great Lakes Ice Cover Mapping With RADARSAT-2 SAR Data
SOAR ID number: 2153
Name: George Leshkevich (co-PI, Son V. Nghiem)
Affiliation: NOAA Great Lakes Environmental Research Laboratory
Address: 4840 South State Road, Ann Arbor, MI 48108, USA
Tel.: 734-741-2265
E-mail: George.Leshkevich@noaa.gov
Sector of Application: Cryospheric Science (Lake Ice)
Number of scenes planned: 10
Number of scenes acquired: 11

Abstract and Benefits

The objective of this project is to use RADARSAT-2 data to continue the development of advanced algorithms to classify and map ice cover on the Laurentian Great Lakes started using synthetic aperture radar (SAR) data from ERS-1, ERS-2, and RADARSAT-1. NASA JPL and NOAA GLERL together with support from the US Coast Guard have carried out field experiments on the upper Great Lakes, which have resulted in a comprehensive C-band fully-polarimetric backscatter signature data set up to 60^{o} incidence angles for various ice types and calm open water (Nghiem and Leshkevich, Part 1, 2007) together with "ground truth" data. This unique data set is directly applicable to RADARSAT-2 data (same frequency, all polarizations, and incidence angles) using the dual polarimetric and fully polarimetric (Quad-Pol) capabilities. Providing greater discrimination and less ambiguity than single band, single polarization data, dual polarization and Quad-Pol data at large incidence angles can improve ice type discrimination and mapping that are robust over a wide range of wind speed and direction. At small incidence angles and with a single polarization, RADARSAT-2 results over Lake Superior show that ice and water can be discriminated after which the ice-backscatter library can be applied to classify ice types.

Although the initial algorithm validation showed that the algorithm correctly classified ice types in the ice backscatter library, open water was often misclassified owing to the ambiguity encountered in single polarization data due to variations in wind speed and wind direction over water (Leshkevich and Nghiem, Part 2, 2007). The algorithm is developed for different range of incidence angles, over which radar scattering mechanisms have different characteristics depending on the relative volume and surface scattering at different polarizations. From our measured backscatter library together with the physical scattering basis, the algorithm is partitioned into two regimes: small incidence angles $\leq 35^{o}$, and large incidence angles $> 35^{o}$. For each of these ranges of

incidence angle, the algorithm is developed differently for ice and water identification due to different scattering mechanisms at different incidence angles.

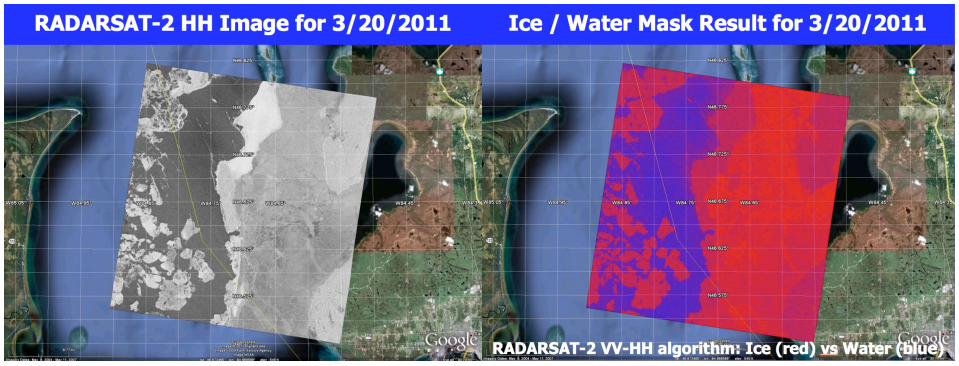
For small incidence angles, single-polarization (either *HH* or *VV*) SAR data can reasonably distinguish between ice and water at different wind speeds and directions. This small-incidence algorithm was tested with RADARSAT-2 Quad-Pol *HH* data collected on March 18, 2009 in the western part of Lake Superior.

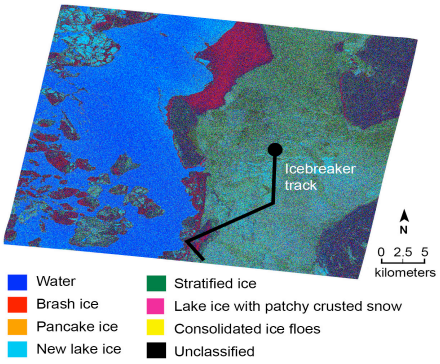
During winter 2010-11 (GLAWEX11), RADARSAT-2 Quad-Pol data with large incidence angle (> 35^{o}) was obtained over Whitefish Bay in Lake Superior coincident with data collection from the icebreaker USCGC Mackinaw. Using our *VV-HH* ratio algorithm, open water and ice cover could be identified in the imagery. Then, our library of C-band backscatter signatures of different freshwater ice types was applied to the imagery to classify and color-code the ice types (see figures). Once fully developed, this algorithm can be used in an automated procedure to obtain ice concentration, ice type, and ice mapping of importance to operational ice breaking and winter navigation as well as winter ecology, fisheries recruitment, and ice cover modeling efforts.

References:

Leshkevich, G.A. and S.V. Nghiem, 2007. Satellite SAR Remote Sensing of Great Lakes Ice Cover Part 2. Ice Classification and Mapping. *Journal of Great Lakes Research*, 33(4):736-750.

Nghiem, S.V. and G.A. Leshkevich, 2007. Satellite SAR Remote Sensing of Great Lakes Ice Cover, Part 1. Ice Backscatter Signatures at C-Band. *Journal of Great Lakes Research*, 33(4):722-735.





SOAR sponsored publications and presentations:

Leshkevich, G. and S.V. Nghiem, Great Lakes Ice Classification Using Satellite C-band SAR Multi-Polarization Data, *Journal of Great Lakes Research,* in press. http://authors.elsevier.com/sd/article/S0380133013000683

Leshkevich, G. and S.V. Nghiem, Great Lakes Ice Cover Mapping with RADARSAT-2 SAR Data. 3rd RADARSAT-2 Workshop, Sept. 29 – Oct. 1, 2010, St. Hubert, Quebec, Canada

Leshkevich, G., Great Lakes Ice Classification and Mapping, Great Lakes International Ice Breaking Conference, Windsor, Ontario, Canada, October 27, 2010

Nghiem, S.V. and Leshkevich, G., Advancing a Satellite Synthetic Aperture Radar (SAR) Ice Classification Algorithm, IAGLR 2011, Duluth, MN, May 30-June 3, 2011.

Nghiem, S.V. and Leshkevich, G. , Toward an Operational Satellite Synthetic Aperture Radar (SAR) Ice Type Classification Algorithm for the Great Lakes, IAGLR 2012, Cornwall, Ont., May 13-17, 2012.

Leshkevich, G., and Nghiem, S.V., Multi-sensor Approach to Ice Type Classification and Ice Thickness Measurement in the Great Lakes, IAGLR 2013, West Lafayette, IN., June 2-6, 2013.

Relevant publications or reports on the project may be submitted either by e-mail or via a FTP site.

RADARSAT-2 FTP site: ftp.asc-csa.gc.ca/users/SOAR/incoming